How mental models impact students' engagement with empathic communication exercises

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Introduction

Numerous studies of engineering practice have provided compelling evidence of the socio-technical nature of the profession and, therefore, the need for a greater focus in engineering curricula on professional skills and orientations (Bucciarelli, 1994; Jonassen, Strobel, & Lee, 2006; Trevelyan, 2007). Compared to other professional skills, however, such as leadership and teamwork (Shuman, Besterfield-Sacre, & McGourty, 2005), the development of empathy in engineering undergraduate programs has received limited attention.

In this study, we examined student reactions to a pedagogical development (a set of four 75-minute modules) designed to introduce engineering students to empathic communication techniques. Our findings point to the need to employ a constructivist view when teaching empathy to engineering students. More specifically, we emphasize the need to attend to students' pre-existing, mental models about what constitutes engineering knowledge and practice. We suggest that teaching empathic communication techniques is not a simple matter of adding an objective set of skills to students' tool kits. Rather, we highlight a range of potential tensions and synergies that may influence how students incorporate such training into their developing understandings of what constitutes engineering knowledge and practice.

Relevant prior work

Prior efforts to integrate empathy into undergraduate engineering programs have varied in their goals and curricula (for an extended discussion see Hess & Fila, 2016). Many of these initiatives productively build on prior work in empathic design and focus on connecting students with users in product contexts (Bell-Huff & Morano, 2017; Burns & Lesseig, 2017; Gray, Yilmaz, Daley, Seifert, & Gonzalez, 2015; Mitchell & Light, 2018; von Unold et al., 2018). For example, Gray et al. (2015) expanded an existing method—the cognitive walkthrough—to encourage students to take on the role of users and "talk through" (Gray et al., 2015, p. 5) experiences with a proposed product or system. This method, "the empathic walkthrough," provides students with a new perspective on the design space through "revealing tacit assumptions they have about the user they are designing for, and externalizing these assumptions by walking through the use of the product or system" (Gray et al., 2015, p. 5).

In parallel to efforts focused on empathy in design settings, an increasing number of studies are examining how empathy can contribute to the complex processes involved in teaching and learning engineering ethics (Gray, de Cresce El Debs, Exter, & Krause, 2016; Hess, Beever, Strobel, & Brightman, 2017; Hess, Strobel, & Brightman, 2017; Hoople & Choi-Fitzpatrick, 2017; James, Svihla, Qiu, & Riley, 2018). Hess, Strobel, et al. (2017), for instance, studied the development of empathic perspective taking as a critical part of ethical decision-making. Their work found that activities such as engaging with different perspectives and participating in role-play exercises where students enacted stakeholders can lead to increased open-mindedness (Hess, Strobel, et al., 2017).

While our approach to teaching empathy to students shares some features with the above-described efforts, it is distinct in the following three ways. First, we view empathy as a

professional skill that facilitates not only better design outcomes but also better relationships with the range of people and environments that engineers come in contact with daily (e.g., our technical peers, supervisors, partners from other disciplines, clients, contractors, and members of the many diverse stakeholder groups that make up “the public” (National Society of Professional Engineers, 2007). This perspective on empathy broadens the scope of skill development beyond designer-user interactions. Second, our approach draws on theoretical frameworks and longstanding pedagogical techniques from the field of social work, a discipline that conceptualizes empathy as an essential skill and orientation of its practitioners. Finally, our approach leverages emerging insights from the neurosciences, which highlight mutually antagonistic relationships between empathic and analytical thinking and the need to consciously recognize and switch between these cognitive modes. We have discussed these distinguishing features of our approach to conceptualizing and teaching empathy in engineering elsewhere (Walther, Miller, & Sochacka, 2016; Walther, Miller, & Sochacka, 2017). In one of these prior works (Walther et al., 2017), we synthesized these insights into context-specific theory of empathy in engineering, illustrated in Figure 1.

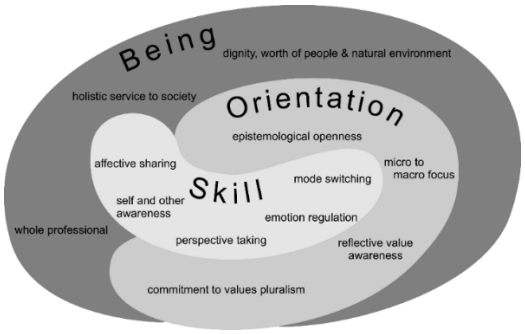

Figure 1. A Model of Empathy in Engineering (Walther et al., 2017, p. 133)**.**

In this model, we define empathy as a skill, a practice orientation, and way of being. The pedagogical approach we describe below is designed to provide opportunities for students to engage with all three dimensions of empathy illustrated in the model.

Overview of the Empathy Modules

Our pedagogical innovation entails a series of four empathy modules, which are integrated into an engineering and society course that is mandatory for all mechanical engineers at our institution. As illustrated in Figure 2, each of the four modules are grounded in a particular set of empathic communication skills, which progressively build on one another.

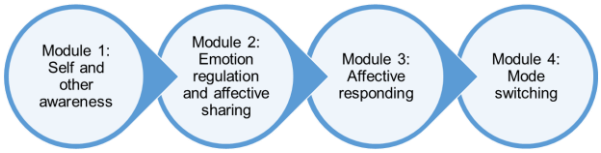

Figure 2. Overview of 4-Module sequence

For example, in the first module, students are guided through activities on encountering others. Students are encouraged to develop an awareness of how they use their Selves (their body, voice, etc.) as the primary tool for building relationships with others. These skills form the foundation for later modules, which focus on recognizing and productively regulating emotions that arise in empathic exchanges, affective responding, and mode-switching.

Each module follows the same structure. First, modules are introduced to students and key concepts are defined and described. Second, students are invited to participate in skill building activities and reflect on those activities in small groups, and then collectively as a

class. Third, students are given an opportunity to practice the skills they have just learned in a real-world engineering context through role play. Finally, the class debriefs together and students are given a prompt to reflect on their experiences.

The reflection prompts for the first three modules ask students to discuss moments of enjoyment or discomfort, and reflect on the role of empathy in engineering. The reflection prompt for the last module is designed according to Walther, Sochacka, and Kellam's (2011) emotional indicator approach. Examples questions used in the prompts are given in Table 1.

Table 1: Examples of reflection questions

Reflection question for Module 2	Reflection question for Module 4
Describe your feelings during the body proximity exercises. Why do you think you felt this way?	When my partner responded empathically to my story, I was surprised to feel that…

Methodology and methods

This study examined the following two research questions: What mental models about engineering and engineering relationships do students bring with them into engineering classrooms? And, how do these mental models impact students' engagement with and understanding of empathic communication exercises?

Data for the study included the students' empathy module reflections (referred to above) for the Spring 2016 (n=36) semester. The research team obtained IRB approval to collect and analyse these data. These data were imported into NVivo 11, a qualitative data analysis software package, and analysed using thematic analysis techniques (Aronson, 1995). Data analysis was conducted primarily by the first author. The research team met weekly to review emergent codes, discuss methodological questions, and collaboratively code selected excerpts from the raw and analysed data to interrogate and validate the findings (Walther, Sochacka, & Kellam, 2013).

Findings

The following sections provide two analytic views on students' experiences. First, we present five themes that form a cross-section of the data at a particular point in the semester that revealed the variation among students' experiences. Second, we present a narrative trajectory that captures the experiences of a student throughout the semester, thus providing a sense of the developmental dynamics observed.

Diverse ways of understanding the role of empathy in engineering

The five themes described here derived from a thematic analysis of student reflections following the third in the sequence of four modules. At this point in the semester, students had engaged with empathy exercises and were in their individual, dynamic processes of sense-making that is illustrated in the variation in students' understandings.

In this module, students are asked to explore two concrete skills that contribute to affective responding: *attending*, utilizing body language to attend to the speaker to convey genuine interest, and *reflecting*, reiterating thoughts ("If I'm hearing you right, you said that …?"; also called paraphrasing) and emotions expressed by a speaker to convey attentiveness and affirm the validity of the speaker's words ("so, you were frustrated when …?"). These skills were practiced first in a pair and then in a role play setting involving an engineer communicating with stakeholders about a community project.

Theme 1: Not engaging with the exercise – 'it's awkward'

> *"I felt as if responding with how the person is feeling is very sarcastic toward the speaker… it felt as if we were talking to a therapist, very unnatural and one sided."*

Here the student describes acknowledging the emotional state of the speaker as uncomfortable and disingenuous – like "talking to a therapist" – and rejects the value of such communication in engineering. Note the role of the contextual setting in this discomfort – reflecting feeling is a common colloquial empathic technique ("no wonder you were angry", "I would've been upset too"). In the setting of an engineering classroom, however, this technique yielded perceived awkwardness. Empathetic communication has been excluded from the domain of engineering such that it is difficult for the student to engage with the technique in this context. Put another way, acknowledging feelings does not seem to be part of this student's mental model of engineering communication.

Theme 2: Communication is key

> *"Public speaking is an essential part of engineering especially since a lot of our calculations are not understood by everyone therefore we must communicate our results to the general public."*

This example highlights common perceptions of empathy held by student participants. The first is that empathy is synonymous with the ability to communicate; this tendency to conflate empathy with communication is perhaps partially fostered by the design of the modules, which focus primarily on the skills dimension of empathy applied to professional practice. The student here is expressing developing insights into empathy, such as the importance of clear communication to foster mutual understanding among people of diverse educational backgrounds. However, there is also a clear sense of expertise intrinsic to the identity of the engineer. The relationship between the engineer and the public is depicted as one-sided, a method for the conveyance of knowledge from the more educated party to the other. This mental model lacks a recognition of the value that can be gained by the engineer from listening to the public; it lacks the empathy to value perspectives beyond technical expertise.

Theme 3: Learning to listen

> *"As an engineer, this activity made me realize how important listening can be. Engineers are required to communicate well, and this means more than just working around problems… With attentive listening, responses come naturally, and in the future I will try to be a better listener rather than just a problem solver."*

This excerpt shows insight into the utility of empathic skills, notably active listening. The pedagogical interventions seem to have not only fostered the development of these skills but have also led to an arguably more comprehensive understanding of what it means it be an engineer. The student articulates that an engineer should use communication to collaborate with others and not just to explain their own opinions. Listening is conceptualized as part of the engineering process, rather than just a means for problem solving or educating the general public. This recognition of the importance of listening is a fundamental reframing of the perception of stakeholders as potential partners in engineering design processes.

Theme 4: Applied Skills

> *"…the paraphrasing part, especially, somewhat actually annoyed me a little… It just did not feel quite right… [The role play] gave me a clearer image of how engineers have to deal with situations like this in reality... As the engineer here, it was important to approach emotional stakeholders with intentions of understanding their side and getting to see things through their perspective."*

This reflection speaks to the interplay of the facets of empathy as both skill and a practice orientation shown in our model of empathy in engineering (Figure 1). At first, the student finds practicing empathic communication skills (specifically paraphrasing what the speaker had said to demonstrate active listening) "annoying." Taking this skill out of an applied context, a pedagogical feature that is arguably present in most technical engineering fundamentals courses, led the student to question its place in the classroom. However, in a role play designed to contextualize interactions within engineering practice, the student found the techniques to be useful and, in fact, critical to developing a working relationship

with stakeholders. The student moved from a skill-based rejection of empathy to recognizing the utility of empathy in practice. It is worthwhile to note that, in prior reflections, this student had written about understanding the skills of empathy in conversation; his reflection here shows a shift in conceptualizing empathy not just as conversational techniques, but as both a mindset and a skillset with which to approach diverse stakeholders in an engineering context.

Theme 5: Empathy as a Way of Being

> *"First, I must state that I no longer wish to become an engineer … I have long battled with choosing the correct major and field for me in which I can both excel at what I love and also help others… this empathic communication module allowed me to do one thing out of those two: help others by enhancing the community. This factor completely aligned with future goals for myself as a whole, and not just as an engineer."*

This excerpt demonstrates another notable interplay between two aspects of the empathy model, in this case empathy as a practice orientation and as a way of being. This student wholeheartedly embraces the concept of empathy as a way of being; it is central to her vision of her life and her career. Interestingly, her exposure to engineering thus far as a second-year student promotes the belief that empathy does not have a place within the practice orientation of engineering, leading her to change her major to find an empathically-oriented career. Her experiences within engineering education have not demonstrated adequate space for her empathic view of her personal self to exist within her professional identity as an engineer. This reflection comes from one of four female students in the class of 36, and suggests that there may be gendered differences in how engineering students respond to empathy-focused teaching innovations. A systematic study of gendered trends is beyond the scope of this article but offers exciting opportunities for future work.

One student's trajectory through the four modules

In addition to the thematic analysis above, we also found it valuable to examine the chronological trajectory of students across all four of the modules, which were purposefully sequenced to build on each other and allow for a continuing exploration of empathy as a set of skills, a practice orientation, and way of being. The trajectory presented below does not represent a linear growth in student understandings of empathy but, instead, a complex interplay between the skill-building activities and discussions prompted by the modules, personal experiences with empathy, and prior mental models of the role of the engineer fostered in engineering education.

Note that the numbers in the list correspond to reflections for each of the four modules.

1. *"We started by… [trying] to find some things we had in common with that person… Engineers tend to be goal focused analytical people, so… nearly everyone probably had figured that they had five minutes per person… I just saw it as an opportunity to talk to three people I didn't know. I think my approach led to a little discomfort in the conversation. I carried on too long… and even joked about overly obvious similarities like gender and major… I probably haven't sold myself as a very good group member or study buddy…"*
2. *" …in reality I think it is far more important to maximize where grant money is going and find plausible solutions. How a stakeholder feels is kind of insignificant when you are discussing starving children. I think as a professional engineer I want to learn my trade well before I directly interact with stakeholder…."*
3. *"I don't think I will work in a field that will put me in the same situation as the engineer here, but, as we saw in the [class] reading, a good engineer seeks a relationship with the community regardless."*
4. *"When my partner responded to my story analytically I felt like he was less worried about me… I was able to see how a person who felt very strongly about a situation could take offense to an overly analytical response, because it almost turns them into a variable in a problem."*

The reflection from Module 1 shows a strong disposition to regard engineering as a purely analytical endeavour. While the student self-identifies as a sociable person, he feels that skill does not have a place within an engineering classroom; rather, he worries he may have presented himself as too jovial in front of his "goal-oriented peers." This relaxed mindset

stands in interesting contrast with the thoughts presented about Module 2. Here the student's foundational perspective of the engineer as the expert emerges as he characterizes stakeholder emotions as insignificant in the face of solving significant problems. This developing engineer hopes to avoid interacting with stakeholders directly until he has perfected his craft; it is thereby evident that he does not view empathic engagement with stakeholders as a fundamental part of the engineering process.

Again in Module 3, without the direct pressure of solving a problem, the student reiterates the importance of a community relationship, an idea likely influenced by the course readings. There is still some degree of removal from directly encountering the issue of empathy in engineering as the student believes he will not face a situation involving an emotional stakeholder in his profession. After the Module 4 role play, however, the student recognizes that although it is not necessarily his preferred communication method, the skills of empathic communication (versus an analytical response) can be extremely relevant in tense stakeholder situations.

This trajectory shows a highly non-linear journey through the modules. These reflections are particularly poignant in the struggle between the professional identity as an engineer and the student's personal identity; the contrast between his view of himself as an amicable person and his view of an engineer as a superior problem solver remains unresolved throughout the reflections. Even in later modules, it is evident that many of the student's preconceived ideas about the engineer as the expert and his questions about the true relevance of empathic skills within engineering practice remain. However, through the contrasting thoughts presented in his reflections, sometimes contained within the same reflection, it is evident that the student is attempting to incorporate this new understanding of empathy within his pre-existing, mental models of engineers, and that this deepening understanding of empathy is subsequently pushing back against such mental models. The juxtaposition of these cornerstones of professional identity formations were common in the students we studied. We suspect that a student such as the one presented here would not necessarily score significantly better on an objective test of empathy skills (Davis, 1983) at the end of the modules, but we believe the contrasting ideas in this non-linear trajectory represent, at the very least, a deepening exploration of the role of empathy within engineering and a developing understanding of the complexity of working socio-technical systems.

Implications and Recommendations

First, our findings demonstrate that students come to the classroom with pre-existing mental models about what engineering is, and how engineers (should) interact with others. In line with constructivist theories of learning (Merrell, 1991), these prior mental models have significant impacts on how students engage with the experiences in the empathy modules. More specifically, some preconceptions about engineering, for example, around notions of expertise that lend authority to the engineer, may provide tensions with students' efforts to develop deeper, embodied understandings of empathy as an orientation that frames stakeholders as potential partners in their professional endeavours. Similar tensions arose around the inherent emotional facets of communication revealed by the modules. Some students struggled to reconcile this dimension of interpersonal communication with their assumptions about the objective, dispassionate stance of the professional engineer. As instructors, the success of our efforts to foster empathy in our students depends on our ability to understand these mental models so that students can integrate new knowledge, skills, and processes into, ideally, more sophisticated mental models of their own professional selves. At one level, understanding students' prior mental models is critically important in planning empathy exercises. The learning experiences we offer students should both expose students gradually to empathic skills and be situated in pedagogical contexts that are intentionally connected to the development of their engineering identities. The findings show that a focus on skills development without the context of professional

application can lead students to discard the experiences as irrelevant or engage in them as a private individual without connecting them to their professional self-perception. Beyond these implications for instructional design, this constructivist perspective becomes particularly important for facilitating students' experiences and debriefing sessions in the classroom. The quotes show that the experiences are often emotional for students and present significant tensions throughout. Without a recognition of these tensions between prior and developing understandings of engineering, we cannot hope to successfully facilitate these development processes in ways that also model the empathic orientations and skills for students.

The second implication from the analysis suggests that the process of developing new understandings regarding the role of empathy in engineering is rarely linear or without conflict. The data analysis revealed that there was significant variation across students' experiences and responses across the group, a level of disconnect that, as instructors, we need to accommodate in a whole class debrief. Considering the responses presented in the reflections after module three, some students will reject the learning experience entirely, while others are beginning to engage in transformational processes concerning their professional identity. Being aware of this range can put us in a position to facilitate a shared experience and discussion that does not invalidate students' experience at either end of the range and perhaps opens opportunities for beneficial peer influences in a socio-cultural learning dynamic. We thus encourage instructors to acknowledge and embrace this conflict and embrace modelling of empathy as a core pedagogical tool. Over the past five years of teaching these modules, we have come to the understanding that it is not our place to be the "experts" but, rather, to empathize with the emotional experience that can accompany a student who is in the process of reconsidering their pre-existing mental models.

A third implication of the findings and the discussion above concerns fundamental questions of assessment in the context of facilitating a personally relevant, dynamic, and tension-laden development process. More specifically, while students can be assessed on their knowledge of specific affective responding techniques (attending, reflecting emotion etc.), the most significant learning may lie in unresolved inner conflicts, which are more challenging to evaluate in a traditional view of learning outcomes. The data analysis suggests two features of student learning that may inform a more nuanced view on assessment of these types of development processes. First, we cannot assume a gradual progression of students towards a common understanding. Students' experiences showed tensions and signs of cognitive disconnect and ultimately arrived at very different, individual understandings. Second, the data indicated that the development processes we are interested in as educators in this context extend beyond a single course and likely beyond the students' entire university experience. These two features suggest that a productive way to provide evidence of students' learning may not lie in the attainment of outcomes but rather in the depth and genuineness with which they engage in the learning processes. One approach may be to use collective and individual reflection techniques to make this quality of their learning visible, an endeavour that provides both starting points for assessing student development and, at the same time, an opportunity to actively further their professional growth.

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